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U. S. DEPARTMENT OF AGRICULTURE

DIVISION OF CHEMISTRY

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RECORD

OF

EXPERIMENTS WITH SORGHUM

IN

1893

BY

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF CHEMISTRY,
Washington, D. C., January 31, 1894.

SIR: I have the honor to submit for your inspection and approval the manuscript of Bulletin No. 40 of the Division of Chemistry, being a record of experiments conducted in the culture of sorghum during the year 1893 by authority from you, under my direction.

Respectfully,

H. W. WILEY,
Chemist.

Hon. J. STERLING MORTON,
Secretary.

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EXPERIMENTS WITH SORGHUM IN 1893.

WORK AT THE MEDICINE LODGE STATION.

The experiments in the improvement of sorghum as a sugar-producing plant were continued at Medicine Lodge, Kans., during the season of 1893. A series of misfortunes attended the cultural work at this station. The first planting was entirely destroyed by chinch bugs during the early part of June, so that by the 15th there was nothing left of the first planting except one plat. The invasion of the chinch bug is largely due to the practice of rotating the crops of sorghum with other cereal crops in which the chinch bugs easily breed. It is, therefore, deemed advisable in future experiments of this kind to use other crops in the rotation. Root crops, vines, or, if possible, alfalfa, where it can be grown, would prove superior to the cereals as rotating crops.

CLIMATIC CONDITIONS.

The season as a whole was the driest which has occurred in that part of Kansas in a great many years. The spring was exceedingly hot and dry, and there was no rainfall during the whole of the months of March and April, and very light showers in May. The planting time was preceded by eighty days of hot, dry weather, with high winds and not a drop of rain. During the latter part of May there was a rainfall amounting to 2.18 inches, but it fell at such intervals as to prevent its penetrating the soil to any great depth. During June 1.21 inches of rain fell, and this also in light, scattered showers. The month was very hot, with hot winds on several days. During July 1.44 inches of rain fell. The temperature during the whole of July was exceedingly high, with hot winds. During August 2.95 inches of rain fell, but the weather was exceedingly hot, and there was a series of hot winds. The thermometer during this month frequently registered 100 ° F. and over in the shade. The rain also fell in light showers. During September 3.40 inches of rain fell, and this was the first time since planting that the land was wet to a depth of 4 inches. As a result about the only growth the cane made was during the month of September. In October there was scarcely any rain, only 0.14 inches. A light frost was observed on the

the 3d and 5th, but no damage was done; but on the 8th the frost was severe enough to kill the leaves of the cane. Cane which was planted early in April did not come up until May on account of the ground being too dry to germinate the seed.

PRECAUTIONS OBSERVED IN PLANTING.

The character of the preparation of the soil and its cultivation was the same as in previous years. The planting was done upon the plats of the station as usual, and several farmers residing in the vicinity of Medicine Lodge were also employed to grow plats of 1 acre each on the conditions of previous years, viz, that the plats should be at least 300 yards from any other crop, such as broom corn, the pollen of which could possibly influence the seed. These precautions are necessary in order to secure the varieties in a pure and uncrossed form.

CHARACTER OF THE CANE HARVESTED.

In spite of the fact that the cane scarcely grew at all during the summer, that the whole of the growth was made during the month of September, and that the frosts were exceedingly early, a fair crop was obtained on most plats, and with sufficient maturity before the frosts to secure seed selection. The result, however, would naturally be to depress the content of sucrose in the cane, and thus apparently show a deterioration during the year. This deterioration must be considered to be only apparent, however, inasmuch as the good qualities which have been secured by a long series of selections are still contained potentially in the seed, although the actual content of sugar of the stalks bearing the seed for the present season has fallen far below that of some of the previous years. It is not to be doubted that the canes produced by these seeds under favorable climatic conditions will continue to show the permanent improvement which has been secured by the processes of selection.

On the appearance of the chinch bugs in the fields they were treated with the infected bugs, which have proved so valuable as destructive agents to the chinch bugs in Kansas. By this and other vigorous treatment one block was saved from the ravages of these pests.

SEED SELECTIONS AND CHEMICAL ANALYSES.

The work of seed selection and of chemical analysis on the station was begun on the 4th of September, ten days later than usual. The comparison of the average of the varieties with the same varieties of last year almost uniformly shows a deterioration in the content of sucrose, and in many instances a very great deterioration in the purity of the juices.

The average quality of the canes of the two years and of the different varieties is shown in the subjoined table:

Average quality of canes for the years 1892 and 1893.

Variety.	1892.		1893.	
	Sucrose.	Purity.	Sucrose.	Purity.
	Per cent.		*Per cent.*	
Collier	18·99	77·13	15·40	72·70
McLean	18·42	77·99	15·20	77·20
Link Crosses	18·36	77·04	16·42	75·50
No. 112	17·20	75·00	15·80	69·60
Link	17·05	74·09	14·30	73·30
No. 8 X	16·75	75·40	14·80	77·69
No. 161	16·56	76·00	16·64	60·00
Colman	15·79	72·10	15·54	74·60
Folger	15·53	72·20	15·40	68·14

By reason of the limitation placed upon the funds which were to be expended at the station, the amount of work undertaken was far less than that of previous years. As an illustration of this the number of seed selections may be instanced. During the season 14,956 selections of seed for propagation were made, against 49,912 last year. The number of seed heads of each of the standard varieties selected during the past season is as follows:

Number of seed heads selected.

Amber	1,100	Orange	1,597
Folger	2,964	No. 112	1,757
McLean	345	No. 161	151
Colman	868	No 8 X	473
Link	260	Collier	5,441

To those who have not followed closely the work of the Department in the improvement of sorghum by the selection of seed of canes having high sugar qualities, it may not be void of interest to give in tabular form a statement of the number of analyses which have been made for this purpose. Beginning with the year 1888, when the first selections of seed on scientific principles were made, the number of seed selections made in each year for the different standard varieties can be seen from the following table:

Number of seed selections of standard varieties, 1888–1893.

Variety.	1888.	1889.	1890.	1891.	1892.	1893.	Six years.
Amber	10	25	12	964	4,319	1,100	6,430
Folger	10	23	32	5,479	13,722	2,964	22,230
Colman	.....	22	44	2,236	15,326	868	18,496
Collier	4	17	18	3,077	10,822	5,441	19,379
McLean	.....	.....	12	4,730	5,904	345	10,991
Link	25	62	147	124	5,310	260	5,928
No. 8X	.....	.....	.....	255	2,223	473	2,951
No. 112	.....	7	20	220	1,621	1,757	3,625
No. 161	.....	18	38	551	1,669	151	2,427
Orange	12	24	5	306	742	1,597	2,686
Various	2,058	13,956	14,668	11,364	28,287	.....	70,333
Total	2,119	14,154	14,996	29,306	89,945	14,956	165,476

It is hardly necessary to call attention to the fact that the number of selections made was far inferior to the number of analyses. Only an approximate estimate can be made of the number of juices examined for seed selections, but it may be safely stated that only about one in each three was found of sufficient value in its preliminary analysis to warrant its selection as seed. If, therefore, the numbers given in the table are multiplied by three it will approximately give the total number of individual canes examined in this work. It is true that the skilled eye can and does select from the standing canes only those which seem likely to have the highest qualities; therefore the number of seed heads rejected is far less than would occur if the whole number of stalks of cane as they stand in the field was subjected to analysis.

The two seasons of 1892 and 1893 are in some respects complementary. The former favored in an abnormal degree the development of a high content of sucrose, while the latter in as marked degree retarded it. A mean of the two seasons would be a better representation of progress than the data of either season taken alone. The dominant influence of climatic conditions is well illustrated in the diagram (*see* page 25) showing, graphically, the progress of seed selection.

IMPROVEMENT OF CANE BY INTENSIVE CULTURE.

There is yet much to be done in the way of scientific selection before we can say that the sorghum cane has reached approximately its maximum of development, and even when it has reached this only the most scientific care in the production of seed as a special branch of sorghum culture will maintain the high grade which has been acquired. Not only should the method of selection which has been practiced by the Department be continued, but in addition to this efforts should be made toward the improvement of the cane by intensive culture. So far we have relied solely upon the accidental variations of the plant, as caused by the environment, to produce those qualities which we desired to preserve by selection. No systematic attempt has been made to provide an environment for the special purpose of stimulating the plant to development in a given direction. The great and powerful forces of varied forms of culture and of different kinds of fertilization have never been brought to bear upon this plant for the purpose of improving it in its sugar-producing qualities. Enough has been done, however, to place the sorghum plant in a position to attract the attention of the capitalist and scientist.

THE DISPOSITION OF CANE-SEED HEADS.

The seed heads which bear in their vital principle the effects and results of this long series of experimental work have been distributed as follows: A few typical seed heads of each standard variety have been preserved in the Department for future propagation should it ever

be desired to renew this line of work. To those experiment stations expressing a willingness to continue the work of improvement have been sent high-grade pedigreed seed heads together with a full description of the line of descent and of the sugar-making properties of the different ancestors from the time of beginning the selections to the present. The rest of the seed was put up in 4-ounce packages and distributed to persons in favorable localities interested in the culture of sorghum cane of high grade. A complete record of the seed heads sent to the stations with their pedigrees has been preserved in the archives of the Division of Chemistry. It is to be hoped, in the interest of a great industry, that this line of development may secure further attention from individuals or experiment stations. It is, moreover, very suggestive in respect of other farm crops, that these also can be greatly improved in their desirable qualities by the same line of experimental research which has succeeded in bringing out of an unpromising sorghum plant a promising source of sugar. Taking advantage of accidental variations of seed, changes in environment and intensive culture, we may be able to produce with almost any farm crop improvements in its qualities which will be of interest and value both to the producer and the consumer thereof.

RECORDS OF SEED SELECTIONS.

The analytical data representing the seed selections for the past six years are contained in large record books, which are preserved in this division. The entries aggregate approximately a quarter of a million, and their publication would be of little value as compared with the great cost attending it. Nevertheless, this record is most useful in the case of the tracing of the pedigree of any of the seed heads which are preserved from year to year. In the conduct of the work less attention has been given to the preservation of individual pedigrees than to general selection; therefore, it has often occurred that individual canes from mixed seed representing a whole plat have shown better sugar-making qualities than the individual canes with unbroken individual pedigrees. In such cases succeeding selections have been made from the individual canes from mixed seeds. The pedigrees of these canes, of course, are as perfect as those whose individual parentage has in each case been preserved, but it is not possible to trace them individually further back than the year of their production from the mixed seed, which was itself the result of placing together the seed produced by all the collateral branches of a given plat. In the descriptions which follow, however, it has been thought best to give the individual pedigree of the leading varieties, although it does not in every case, or in any case, perhaps, represent in the final outcome the best results of the selection. The fact that the selections from collateral branches have in many instances shown higher sugar-producing qualities than those in the direct line of

descent through given individuals, shows the wisdom of the method of selection from a numerous parentage and of the continuation of the selections from the mixed seeds, commonly called in this report "bulk seeds."

It should not be inferred by anyone that the expression "bulk seed" casts in any way any doubt upon the line of descent. On the other hand, the seed of the Colman variety, which is now in the possession of the Department and which represents the highest potential sugar possibilities of the best sugar-making sorghum variety, has its direct line of descent from the original selection in 1887, but only a limited number of seed heads has the direct individual line of descent.

At Sterling the small areas planted to each individual seed head were called "plats," while at Medicine Lodge similar areas were called "blocks." They are indicated in the tables by "P" and "B," respectively.

The pedigree of the Colman cane may be taken as an illustration of the meaning of the tables. The peculiar appearing cane produced by a cross of Amber and Orange in 1887 was planted in 1888 on Plat 153; meaning Plat 153 at Sterling. There were selected from this plat five canes, the serial number of one of which was 652. This also was the best cane of the five selected. Its percentage of sucrose and purity is given in the table. Number 652 was planted in 1889 on Plat 293, and 140 canes were selected from this plat. One of these, 13097, was planted in 1890 on Plat 130, and 49 canes were selected from the progeny of this seed head, one of which, 7737, was planted in 1891 on Plat 227 at Sterling. From this progeny 162 seed heads were selected, one of which, 21964, was planted in 1892 on Block 41 at Medicine Lodge. From this parent 25 seed heads were selected, one of which, 16830, was planted on Block 51, at Medicine Lodge, in 1893, and 31 seed heads were selected from the progeny of this parent for future planting.

It is seen by the table of pedigrees that the line of descent for the individual cane is not directly through the best canes in each case. An attempt was made to preserve the line of descent through the best canes, but accidents of various kinds have prevented this being done. While the canes directly propagated were not always the best (meaning highest in sugar content of juice), they were, however, always of very high grade.

The second table shows the pedigree of another seed head of the Colman variety, and this is given to show the tendency to reversion that often manifests itself and to emphasize the danger of depending on a single individual pedigree. This is the best illustration of reversion that has been observed in the direct line of descent.

All the nineteen canes produced in 1892 on Block 11 from parent 16818 are still in the possession of the Department, and can be used for continuing the individual strain through that line, although it is much less promising than many of the collateral branches.

DESIRABILITY OF PRESERVING INDIVIDUAL PEDIGREES.

As was intimated above, the practical value of direct pedigreed seed is probably found more in the selections from the bulk or mixed seeds than in the preservation of individual pedigrees. Yet it has been deemed of interest from a physiological as well as practical point of view to preserve a direct line of descent for all the standard varieties. It is desirable that the State experiment stations, in localities suited to the growth of sorghum of a high sugar content, should coöperate with the Department in the preservation of these individual lines of descent and to all such stations seed heads will be sent, together with their pedigrees, provided they will undertake to preserve carefully these individuals from admixture with any other variety and to make analyses and selections from the progeny, so that the line of descent can remain unbroken in the individual.

DESCRIPTIONS OF PEDIGREED SEED.

Colman I.

This variety originated in a cross between Amber and Orange, selected in 1887 at Sterling by A. A. Denton. It has been grown six years, and the following pedigree showing direct individual descent from 1887 to 1893 represents four years at Sterling and two at Medicine Lodge, to which place it was transplanted in 1892.

Pedigree of Colman I cane, 1888–1893.

Year.	Plat or block.	Serial No.	In juice.	
			Sucrose.	Purity.
			Per cent.	
1888	P. 153	652	17·3	76·4
	Best cane	652	17·3	76·4
	Plat average	(5 canes)	15·8	76.0
1889	P. 293 (planted from serial No. 652; 1888)	13097	18·9	80·9
	Best cane	13103	20·7	80·8
	Plat average	(140 canes)	17·3	72·7
1890	P. 130 (planted from serial No. 13097; 1889)	7737	18·3	79·5
	Best cane	7749	18.0	82·6
	Plat average	(49 canes)	17·3	79·4
1891	P. 227 (planted from serial No. 7737; 1890)	21964	16·6	76·5
	Best cane	21981	16.0	80.0
	Plat average	(62 canes)	14·9	73·4
1892	B. 41 (planted from serial No. 21964; 1891)	16830	18.0	77·7
	Best cane	16827	18·2	78·2
	Plat average	(25 canes)	16·8	75·7
1893	B. 51 (planted from serial No. 16830; 1892)	8507–8537	.....	.....
	Best cane	8536	17·4	80·0
	Plat average	(31 canes)	16·6	76·9

No other member of the group to which 16830 (1892) belonged was planted in 1893. Hence the 31 canes selected in 1893 are the sole direct individual descendants through the above line. The collateral branches, however, furnished a progeny numbering 837, which originated from the seed head selected in 1887, descending through other lines.

Colman II.

The following table shows the direct individual descent of another seed head of the Colman variety from 1887 to 1892:

Pedigree of Colman II cane, 1888–1892.

Year.	Plat or block.	Serial No.	In juice.	
			Sucrose.	Purity.
			Per cent.	
1888	P. 153	1134	16·9	75·1
	Best cane	652	17·4	77·3
	Plat average	(5 canes)	15·7	75·1
1889	P. 291 (planted from serial No. 1134; 1888)	13056	18·4	73·9
	Best cane	13038	17·3	83·9
	Plat average	(16 canes)	17·5	78·1
1890	P. 129 (planted from serial No. 13056; 1889)	8633	17·8	80·6
	Best cane	8620	17·0	83·3
	Plat average	(26 canes)	17·1	78·3
1891	P. 75 (planted from serial No. 8633; 1890)	16818	17·0	75·2
	Best cane	16679	17·8	80·9
	Plat average	(378 canes)	16·8	74·8
1892	B. 11 (planted from serial No. 16818; 1891)	11358–11376		
	Best cane	11368	16·2	75·2
	Plat average	(19 canes)	14·8	72·0

From the 1890 parent 8633 were selected in 1891, 378 canes, of which the following were planted and selected from in 1892: 16660, 16669, 16688, 16714, 16755, 16760, 16785, 16798, 16800, 16804, 16806, 16812, 16818, 16826, 16830, and 16999. These constitute the collateral branches, the 1893 progeny of which was destroyed by chinch bugs. The 19 seed heads, 11358–11376, 1892, are preserved by the Department and the direct individual strain may be continued therefrom.

Collier.

This variety came originally from Africa. It was grown by the Department in Washington under the direction of Dr. Collier in 1882, and gave, as a mean of 15 analyses, 13·5 per cent sugar. Grown four years at Sterling, it was transplanted to Medicine Lodge in 1892.

The entire individual direct line of descent was lost the past season by ravages of chinch bugs on the plats planted with pedigreed heads. In 1892 were grown 7 blocks of Collier, of which 1 was from pedigreed heads (B. 17), another partially, and the rest from bulk from Sterling crop of 1891. In the 1893 planting preference was given the descendants of B. 17 (direct pedigree) and 3 blocks were planted from them. The entire planting on these blocks was destroyed by the bugs and the line of descent lost. The 1893 selections were from plantings of heads derived from bulk plats of the previous year.

Pedigree of Collier cane, 1888–1892.

Year.	Plat or block.	Serial No.	In juice.	
			Sucrose.	Purity.
			Per cent.	
1888	P. 39	Mixed seed from 7 heads.		
	Best cane	13947	14·0	73·0
	Plat average	(7 canes)	13·4	72·4
1889	P. 254 (planted from mixed seed, 7 canes; 1888).	12379	18·6	79·4
	Best cane	11971	19·8	81·2
	Plat average	(111 canes)	17·3	77·0
1890	P. 117 (planted from serial No. 12379; 1889).	8880	17·4	78·6
	Best cane	8932	19·0	88·4
	Plat average	(114 canes)	16·9	77·7
1891	P. 84 (planted from serial No. 8880; 1890)	17567	18·0	79·0
	Best cane	17567	18·0	79·0
	Plat average	(35 canes)	17·2	74·3
1892	B. 17 (planted from serial No. 17567; 1891)	43959–43987		
	Best cane	43959	19·0	86·0
	Plat average	(29 canes)	17·6	75·2

As stated above the individual branches were lost in 1893, but the group, 43959–43987, 1892, is preserved by the Department and the direct individual line of descent may be continued therefrom.

McLean.

This variety was received from Hon. Peter McLean, under-secretary of agriculture, Queensland, in 1890, and in that year was known as "Lots Nos. 126 and 127." In the following year the variety was named McLean. It was grown two years at Sterling and transplanted in 1892 to Medicine Lodge, where it exhibited its superior sugar character even more markedly than at Sterling. Aside from the Collier it was the richest variety grown in 1892.

Pedigree of McLean cane, 1890–1893.

Year.	Plat or block.	Serial No.	In juice.	
			Sucrose.	Purity.
			Per cent.	
1890	P. 126	Mixed seed from 13 heads.		
	Best cane	11293	15·7	78·1
	Plat average	(13 canes)	15·6	75·7
1891	P. 548 (planted from mixed seed, 12 heads; 1890).	8973	17·1	74·7
	Best cane	9190	17·7	81·5
	Plat average	(321 canes)	16·6	73·2
1892	B. 58 (planted from serial No. 8973; 1891)	35369	19·3	79·3
	Best cane	35361	19·7	83·4
	Plat average	(63 canes)	19·2	80·5
1893	B. 45 (planted from serial No. 35369; 1892)	7012–7026		
	Best cane	7012	17·0	82·1
	Plat average	(15 canes)	15·8	76·4

From parent 8973, 1891, was produced in 1892 the group 35325 to 35387, inclusive. Of these 63 canes, the following were planted and selected from in 1893: 35337, 35343, 35366, 35367, and 35369. These parents, with the exception of 35369, given above, constitute the collateral branches of the above pedigree and their characters follow:

Collateral branches.

[Springing from parent 8973 of 1891.]

	Parents in 1892.			
	35337.	35343.	35366.	35367.
Serials, 1893	6992–6999	7000–12	6912–19	6981–91
Number of selections	8	12	8	11
Best cane, sucrose and purity	17·5–80·7	16·1–81·7	15·1–79·9	16·6–84·3
Best cane number	(6996)	(7002)	(6913)	(6981)
Plat, mean sucrose and purity	16·6–79·4	15·9–76·1	14·1–72·7	15·1–75·1

There are thus accounted for 54 canes in the 1893 progeny of parent 8973 of 1891 through its progeny planted and selected in 1893. As in the case of the Colman variety, many of the 1892 descendants of other progenitors than 8973 (1891) were planted in 1892, giving rise, in 1893, to a progeny numbering, aside from those accounted for in the above, 291. Had the season of 1893 been more favorable and the ravages of chinch bugs less disastrous, many more selections would have been made in the variety to positively assure its continuance, as it appears to require only careful selection with regard to physical improvement to render it the equal of the other three standard varieties.

Folger.

This variety originated in selections from Amber, in Iowa, by Mr. A. S. Folger. The selected seeds were planted at Sterling in 1888, where the variety was continued until transplanted to Medicine Lodge in 1892.

Pedigree of Folger cane, 1888–1893.

Year.	Plat or block.	Serial No.	In juice.	
			Sucrose.	Purity.
			Per ct.	
1888		49	10·8	70·2
1889	P. 205	11566	15·3	74·7
	Best cane	11567	16·5	80·5
	Plat average	(7 canes)	14·1	76·5
1890	P. 110 (planted from Serial No. 11566, 1889; the progenitor of 14404, 1891; from average seed grown on plat 110 this year:			
	Best cane	7149	19·6	84·4
	Plat average	(6 canes)	18·0	79·5
1891	P. 593 (planted from seed grown on plat 110)	14404	15·2	69·7
	Best cane	14405	15·8	79·0
	Plat average	(456 canes)	13·9	67·5
1892	B. 5 (planted from Serial No. 14404, 1888)	6449	17·1	77·3
	Best cane	6432	17·8	82·5
	Plat average	(56 canes)	17·1	76·3
1893	B. 32 (planted from Serial No. 6449, 1892)	4135–4203		
	Best cane	4151	19·7	88 3
	Plat average	(69 canes)	18·6	79·8

In 1892 there were produced and selected, from the progenitor, 14404, grown the year before, the 56 canes numbered 6429 to 6484, inclusive. Had all these canes been planted in 1893 there would have been produced 56 collateral branches springing from the ancestor 14404, of 1891. Inasmuch, however, as many other equally good canes had been selected from other parents, it was deemed advisable to extend the collateral branches as far as practicable over a wide range of parentage. Therefore, in the crop of 1893 there are found but 3 descendants of the progenitor 14404, of 1891, viz, No. 6449 (given in the pedigree), 6433 and 6436, of 1892. Serials 6433 and 6436, therefore, become the collateral branches, and the character of their progeny, in 1893, is seen thus:

Collateral branches.

[Springing from parent 14404 of 1891.]

	Parents in 1892.	
	6433.	6436.
Serials, 1893	91–95, 4618–4642	757–769, 2885–2941
Number of selections	29	50
Best cane, sucrose and purity	18, 4–77, 7	18, 9–80, 5
Best cane, serial	(4640)	(2937)
Plat, mean sucrose and purity	15, 9–69, 4	16, 7–71, 7

The above line of descent accounts for only 159 descendants of the 1888 parent, which were harvested in 1893, there being a total of 2,964 canes selected which are derived from the original parent through lines of descent similar to the above—broken only in 1890, when the progenitor of the succeeding crop (1891) was taken from average, or "bulk" seed, of the preceding season (1889).

SELECTIONS FOR PROPAGATION IN 1894.

The selections of seed heads for special propagation in 1894 have been based upon the general principles guiding similar selections during the past few years. The seed heads of those canes have been taken whose juices showed the best sugar-making properties, as indicated by combined high sucrose and purity. The selections are of two kinds, namely, (1) those for the purpose of preserving the individual pedigrees, and (2) those selected especially on account of their sugar-making properties and representing, chiefly, the collateral branches of the direct line of descent.

SELECTIONS OF COLMAN CANE.

The selections for direct line of descent are taken from block 51, serial Nos. 8507–8537, inclusive. This family has the direct individual pedigree previously given.

The seed heads selected for special propagation for continuing the direct line of descent are Nos. 8503, 8509, 8522, 8524, 8525, 8531, 8534, and

8536, and these are marked with a star in the table. The seeds of the other heads can be mixed and the collateral branches continued through these mixed seeds. The analyses of the juices of each of the individual canes selected for propagation follow:

Serial No.	Sucrose.	Purity.	Serial No.	Sucrose.	Purity.	Serial No.	Sucrose.	Purity.
	Per cent.			*Per cent.*			*Per cent.*	
8507	16·7	77·3	8518	16·7	75·7	8529	15·9	73·6
8508	17·2	*83·1	8519	15·3	74·2	8530	17·1	75·7
8509	17·3	*82·1	8520	16·7	77·3	8531	17·5	*79·6
8510	15·9	69·8	8521	16·7	77·3	8532	16·9	74·0
8511	15·9	73·6	8522	16·7	*79·5	8533	16·1	74·6
8512	15·9	70·1	8523	17·2	83·5	8534	16·4	*79·6
8513	16·3	75·2	8524	17·2	*90·5	8535	17·2	76·5
8514	17·0	75·2	8525	16·4	*83·7	8536	17·4	*79·8
8515	16·9	76·5	8526	16·5	76·4	8537	15·2	70·5
8516	17·4	77·0	8527	16·9	74·8			
8517	15·8	76·0	8528	16·7	72·7	Means.	16·6	76·9

The second family of Colman selected for propagation includes Serial Nos. 6038–6049, grown on block 52, with the following pedigree:

Year.	Plat.	Serial No.	In price.	
			Sucrose.	Purity.
			Per cent.	
1888	P. 153	652	17·3	76·4
1889	P. 293 (planted from seed of Serial No. 652, 1888)	13097	18·9	80·9
1890	P. 130 (planted from seed of Serial No. 13097, 1889)	8375	17·7	83·8
1891	P. 217 (planted from seed of Serial No. 8375, 1890)	Mixed seeds.	16·6	78·5
1892	B. 60 (planted from mixed seeds, 1891)	24520	18·8	78·6
1893	B. 52 (planted from seed of Serial No. 24520)	6038–6049		
	Block average (12 canes.)		16·0	81·6

In this pedigree it will be seen that the individual line of descent was broken in 1892, block 60 of 1892 having been planted from the mixed seeds of plat 217 of 1891. The mean analysis of the juices of 36 of the selected canes of this plat, from which the mixed seeds were taken, gave 16.6 per cent sucrose and 78.5 purity. Plat 217 had a direct individual line of descent from the original selection, in 1887, through No. 652 of plat 153, No. 13097 of plat 293, and No. 8375 of plat 130. The composition of the juices of each of these parent canes is shown in the pedigree.

The seed heads selected for special propagation from this family (Nos. 6040, 6042, 6043, 6044, 6045, 6046, 6047, and 6048) are indicated in the table below by a star. The analyses of the juices of the canes bearing these seed heads follow:

Serial No.	Sucrose.	Purity.	Serial No.	Sucrose.	Purity.	Serial No.	Sucrose.	Purity.
	Per cent.			*Per cent.*	*Per cent.*		*Per cent.*	
6038	13·8	72·2	6043	15·5	*81·1	6048	16·0	*81·2
6039	14·5	77·0	6044	16·8	*88·3	6049	15·2	77·9
6040	17·1	*83·0	6045	17·5	*89·7			
6041	15·4	77·0	6046	16·2	*84·8	Mean...	16·0	81·6
6042	16·9	*84·1	6047	16·9	*83·7			

The third group of Colman canes selected for special propagation is numbered 8460 to 8472, inclusive. They were grown on block 51 according to the following pedigree:

Year.	Block or plat.	Serial No.	In juice.	
			Sucrose.	Purity.
			Per cent.	
1888	P. 153	652	17·3	76·4
1889	P. 293 (planted from seed of serial No. 652; 1888).	13097	18·9	80·9
1890	P. 130 (planted from seed of serial No. 13097; 1889).	Average seed	.....	.....
1891	P. 562 (planted from average seed; 1890)	do	.....	.....
1892	B. 41 (planted from average seed; 1891)	17148	16·0	78·9
1893	B. 51 (planted from seed of serial No. 17148; 1893).	8460–8472	.....	.....
	Block average	.....	16·2	83·4

In this pedigree the canes at Sterling in 1891, as well as those at Medicine Lodge in 1892, were grown from mixed seeds of high grade, but the average analyses of the juices of the canes bearing them have not been preserved.

The selections from this family are made with especial reference to the purity of the juices rather than to the percentage of sucrose.

The individual seed heads selected for propagation were produced by canes 8460, 8461, 8462, 8464, 8465, 8466, 8467, 8469, 8470, and 8471, and are marked in the table by a star. The composition of the juices of the canes bearing these seed heads follows:

Serial No.	Sucrose.	Purity.	Serial No.	Sucrose.	Purity.	Serial No.	Sucrose.	Purity.
	Per cent.			*Per cent.*			*Per cent.*	
8460	16·1	*81·3	8465	16·7	*88·3	8470	16·9	*89·9
8461	16·7	*80·4	8466	16·8	*87·5	8471	16·8	*84·4
8462	16·2	*85·7	8467	16·8	*89·4	8472	16·5	79·7
8463	14·6	72·2	8468	13·5	70·8			
8464	16·0	*84·2	8469	17·5	*90·2	Mean...	16·2	83·4

SELECTIONS OF COLLIER CANE.

As has been before stated, the individual progeny of the Collier were lost in 1893 by the ravages of the chinch bug. Fortunately, however, a direct line of descent has been preserved from seed heads selected in 1892, which were not planted in 1893, and the individual line of descent can be continued through these selections. The pedigree of this family is the one previously given, showing its direct line of descent from 1887 to 1892, inclusive.

The individual selections for special propagation are Nos. 43959, 43961, 43974, 43976, and 43979, and are indicated in the table below by a star. The analyses of the juices of the canes of this family follow:

Serial No.	Sucrose.	Purity.	Serial No.	Sucrose.	Purity.	Serial No.	Sucrose.	Purity.
	Per cent.			*Per cent.*			*Per cent.*	
43959	19·0	*86·0	43970	17·2	74·0	43981	16·8	71·1
43960	16·0	69·4	43971	17·6	76·0	43982	18·4	73·1
43961	18·1	*79·3	43972	16·5	75·3	43983	17·8	74·9
43962	17·8	75·6	43973	18·0	76·8	43984	18·1	76·6
43963	18·1	75·9	43974	19·6	*83·3	43985	18·0	75·8
43964	17·5	75·3	43975	17·7	75·9	43986	18·0	74·5
43965	17·7	73·7	43976	16·5	*77·0	43987	18·4	74·0
43966	16·2	67·8	43977	16·6	74·0			
43967	17·4	73·2	43978	17·2	72·1	Mean...	17·6	75·2
43968	16·7	73·2	43979	18·9	*78·0			
43969	17·7	75·2	43980	17·8	74·0			

The second family of Collier also consists of seeds produced in 1892, on B. 17, and which were not planted in 1893, having the following pedigree:

Year.	Plat.	Serial No.	In juice,	
			Sucrose.	Purity.
			Per cent.	
1888	P. 39	Average seed.	13·4	72.0
1889	P. 25 (planted from average seed; 1888)	Canes having 16 to 18 per cent.		
1890	P. 274 (planted from cane having 16–18 per cent.)	11433	Analysis lost.	
1891	P. 108 (planted from serial No. 11433; 1890	21869	17·0	79·4
1892	B. 17 (planted from serial No. 21869; 1891)	42922–42939		
	Plat average		17.0	73·2

The individual seed heads selected for special propagation in 1894 from this family are Nos. 42923, 42924, 42926, 42931, 42932, 42935, and 42936, and are indicated in the table by a star. These selections, as will be noticed, are based on high sucrose rather than on high purity, although the purities of those selected are the highest of the family. The analyses of the juices of the individual canes bearing these seeds follow:

Serial No.	Sucrose.	Purity.	Serial No.	Sucrose.	Purity.	Serial No.	Sucrose.	Purity.
	Per cent.			*Per cent.*			*Per cent.*	
42922	17·7	71·4	42929	16·7	73·8	42936	18·7	*75·7
42923	18·7	*78·8	42930	16·5	72·6	42937	17·0	70.8
42924	17·5	*75·3	42931	16·7	*75·4	42938	16·0	66.9
42925	13·4	Lost.	42932	17·4	*75·0	42939	16·8	65.7
42926	17·8	*75·6	42933	17·0	72·8			
42927	17·1	72.7	42934	16·9	72·8	Mean...	17·0	32.2
42928	17·4	72·4	42935	17·5	*77·3			

The third group of Collier canes selected for special propagation is numbered 13827 to 13932, inclusive, grown on block 38, with the following pedigree:

Year.	Plat or block.	Serial No.	In juice.	
			Sucrose.	Purity.
			Per cent.	
1888	P. 39	Mixed seeds, plat average.	13·4	72·4
1889	P. 254 (planted from mixed seeds; 1888)	....do	16·8	79·4
1890	P. 114 (planted from mixed seeds; 1888)	9165	17·3	82·7
1891	P. 129 (planted from serial No. 9165; 1890)	Mixed seeds	.....	.....
1892	B. 89 (planted from mixed seeds; 1891)	19361	19·0	78·2
1893	B. 38 (planted from serial No. 19361; 1892.)	13827–932	.....	.....
	Block average	.....	15·4	77·2

The individual seed heads selected for special propagation are Nos. 13842, 13845, 13847, 13848, 13850, 13855, 13864, 13866, 13879, 13880, 13895, 13902, 13903, 13904, 13905, 13906, 13907, 13908, 13911, 13912, 13914, 13918, 13921, 13923, and 13930, and are indicated in the table by a star.

The analyses of the juices of the individual canes bearing these seed heads follow:

Serial No.	Sucrose.	Purity.	Serial No.	Sucrose.	Purity.	Serial No.	Sucrose.	Purity.
	Per cent.			*Per cent.*			*Per cent.*	
13827	15·9	80·7	13862	16·5	76·0	13896	15·3	77·7
13828	15·3	77·7	13863	16·5	74·5	13897	15·4	77·4
13829	15·8	79·8	13864	15·5	*82·9	13898	14·7	75·4
13830	13·8	73·8	13865	15·3	77·7	13899	15·0	79·4
13831	13·1	70·1	13866	15·2	*81·3	13900	15·0	76·1
13832	15·7	77·7	13867	14·8	75·1	13901	15·4	79·4
13833	16·5	76·0	13868	15·6	79·2	13902	15·9	*80·7
13834	15·3	74·2	13869	14·4	69·6	13903	17·0	*90·9
13835	13·6	72·7	13870	14·5	73·6	13904	16·6	*84·3
13836	15·4	78·2	13871	16·2	74·7	13905	17·9	*93·1
13837	15·1	76·7	13872	14·7	70·4	13906	17·4	*88·3
13838	14·9	77·6	13873	13·8	71·1	13907	16·9	*81·7
13839	13·3	71·2	13874	14·0	72·2	13908	16·7	*80·7
13840	15·3	78·9	13875	16·1	74·2	13911	17·4	*84·1
13841	15·1	75·9	13876	12·7	67·2	13912	17·5	*81·7
13842	16·8	*85·3	13877	13·1	70·1	13913	13·8	70·1
13843	15·7	79·3	13878	14·0	71·1	13914	15·3	*80·1
13844	14·7	74·4	13879	16·6	*80·2	13915	13·7	71·4
13845	16·3	*82·7	13880	16·0	*83·9	13916	14·5	77·5
13847	16·1	*81·7	13881	16·1	79.7	13917	15·3	76·9
13848	17·3	*83·5	13882	15·2	73·8	13918	16·9	*90·3
13849	14·7	75·7	13883	15·8	76·3	13919	16·2	78·3
13850	17·5	*84·5	13884	16·1	77·8	13920	14·6	68·9
13851	15·5	80·7	13885	14·0	71·1	13921	16·3	*87·1
13852	15·3	75·8	13886	14·8	75·6	13923	16·7	*89·3
13853	16·2	79·0	13887	15·1	73·0	13924	15·6	75·4
13854	15·3	78·9	13888	13·9	74·4	13925	15·7	75·9
13855	16·6	*80·2	13889	16·3	76·7	13928	13·5	72·2
13856	16·0	77·3	13890	15·3	79·7	13929	12·5	65·1
13857	14·3	74·5	13891	14·9	68·7	13930	15·5	*82·9
13858	13·6	69·0	13892	15·6	75·4	13932	17·1	78·8
13859	16·9	77·9	13893	14·7	67·1			
13860	14·6	71·1	13894	15·8	72·8			
13861	14·2	69·6	13895	15·4	*80·2	Means	15·4	77·2

SELECTIONS OF M'LEAN CANE.

The selections for direct individual propagation have the same pedigree as that previously given. They embrace Nos. 7012–7026, inclusive,

grown on block 45, according to the pedigree mentioned. The individual seed heads selected for special propagation are Nos. 7012–7014–7025 and 7026, and are marked with a star. The analyses of the juices of the canes bearing these seed heads follow:

Serial No.	Sucrose.	Purity.	Serial No.	Sucrose.	Purity.	Serial No.	Sucrose.	Purity.
	Per cent.			*Per cent.*			*Per cent.*	
7012	17·0	*82·1	7018	14·3	72·6	7024	12·9	.....
7013	15·3	70·5	7019	15·3	73·6	7025	17·8	*78·5
7014	17·2	*79·3	7020	15·0	76·1	7026	17·2	*79·3
7015	15·3	77·7	7021	15·1	71·6			
7016	16·0	77·3	7022	15·9	76·8	Means..	15·8	76·4
7017	16·0	77·3	7023	16·7	77·0			

The pedigree of the second family of McLean selected for propagation is as follows:

Year.	Plat or block.	Serial No.	Sucrose.	Purity.
			Per cent.	
1890	P. 126	Average seed.	15·6	75·7
1891	P. 548 (planted from average seed, 1890)	10060	17·9	75·8
1892	B. 58 (planted from serial No. 10060, 1891)	34170	18·4	76·4
1893	B. 45 (planted from serial No. 34170, 1892)	6831–6845	.....	.....
	Block average	.....	15·4	77·8

The seed heads are numbered 6831–6845, inclusive, and were grown on block 45, 1893.

The seed heads selected for special propagation are Nos. 6831, 6833, 6837, 6841, 6842, 6843, and 6845, and are marked with a star. The analyses of the juices of the individual canes bearing these seed heads follow:

Serial No.	Sucrose.	Purity.	Serial No.	Sucrose.	Purity.	Serial No.	Sucrose.	Purity.
	Per cent.			*Per cent.*			*Per cent.*	
6831	16·3	*81·9	6837	15·4	*79·0	6843	16·5	*84·2
6833	15·4	*79·4	6838	15·3	73·3	6844	15·1	74·0
6834	15·1	75·9	6839	14·5	72·2	6845	15·6	*81·7
6835	15·0	75·4	6841	15·5	*82·0			
6836	14·7	72·7	6842	15·2	*79·6	Means.	15.4	77.8

SELECTIONS OF FOLGER CANE.

The individual line of descent is represented by the family 4135–4203, inclusive, grown on block 32, 1893, the pedigree of which has been given. The seed heads selected for special propagation from this family are Nos. 4138, 4139, 4140, 4145, 4146, 4151, 4153, 4154, 4155, 4158, 4160, 4161, 4162, 4164, 4165, 4169, 4172, 4173, 4174, 4176, 4178, 4182, 4183, 4184, 4186, 4188, 4189, 4190, 4193, 4194, 4197, and 4199, and are marked in the table with a star.

The analyses of the juices of the individual canes bearing these seed heads follow:

Serial No.	Sucrose.	Purity.	Serial No.	Sucrose.	Purity.	Serial No.	Sucrose.	Purity.
	Per cent.			*Per cent.*			*Per cent.*	
4135	17·8	76·0	4159	18·6	76·5	4183	18·8	*89·5
4136	15·2	73·8	4160	19·0	*81·5	4184	18·9	*81·1
4137	18·8	78·9	4161	18·9	*81·1	4185	18·3	78·5
4138	18·9	*80·8	4162	19·0	*80·1	4186	19·3	*82. 8
4139	18·7	*83·4	4163	18·4	77·3	4187	19·3	79·4
4140	19·6	*83·7	4164	17·9	*80·2	4188	19·4	*83·2
4141	18·1	*77·3	4165	18·7	*87·3	4189	19·6	*80·6
4142	18·0	77·2	4166	18·5	79·4	4190	19·0	*81·5
4143	17·8	76·0	4167	18·5	79·4	4191	18·6	76·5
4144	17·9	73·3	4168	18·1	74·5	4192	18·7	76·9
4145	18·7	*85·6	4169	18·7	*80·2	4193	18·7	*80·2
4146	18·9	*80·8	4170	17·8	73·2	4194	19·2	*86·1
4147	18·3	76·8	4171.	18·7	76·9	4195	18·4	78·9
4148	18·4	74·8	4172	18·8	*80·8	4196	18·9	77·6
4149	18·6	76·2	4173	18·0	*84·5	4197	19·6	*84·1
4150	18·6	79·4	4174	19·0	*93·5	4198	19·1	78·6
4151	19·7	*88·3	4175	18·1	74·4	4199	19·2	*82·4
4152	19·1	78·6	4176	19·0	*81·5	4200	18·9	77·6
4153	19·1	*85·6	4177	18·2	74·9	4201	17·4	74·6
4154	19·2	*82·4	4178	19·3	*86·5	4202	18·7	76·9
4155	18·6	*83·4	4179	18·6	76·5	4203	18·6	76·5
4156	18·5	79·4	4180	17·5	75·1			
4157	18·4	75·7	4181	17·7	72·8			
4158	19·4	*83·2	4182	17·6	*83·8	Means.	18·6	79·8

The second selection of Folger is represented by the family 4298–4316, which has the following pedigree, grown on block 32, 1893:

Year.	Plat.	Serial No.	In juice.	
			Sucrose.	Purity.
			Per cent.	
1888	.....	49	10·8	70·2
1889	P. 205 (planted from serial No. 49; 1888)....	11566	15·3	74·7
1890	P. 110 (planted from serial No. 11566; 1889).	Average seed.	.....	.....
	Plat average.....	.....	18·0	79·5
1891	P. 593 (planted from average seed; 1890) ...	14442	15·1	70·1
1892	B. 5 (planted from serial No. 14442; 1891)...	6767	16·4	77·3
1893	B. 32 (planted from serial No. 6767; 1892)...	4289–4316	.....	.....
	Plat average.....	.....	16·8	77·2

The individual seed heads selected for special propagation are 4301, 4308, 4311, and 4315, and are marked with a star. The analyses of the juices of the individual canes bearing these seed heads follow:

Serial No.	Sucrose.	Purity.	Serial No.	Sucrose.	Purity.	Serial No.	Sucrose.	Purity.
	Per cent.			*Per cent.*			*Per cent.*	
4298	15·1	73·7	4305	15·7	69·8	4312	17·2	73·1
4299	17·3	79·7	4306	16·3	75·8	4313	16·3	72·5
4300	17·3	76·2	4307	15·8	73·5	4314	17·0	79·1
4301	18·0	*83·7	4308	19·6	*87·1	4315	18·0	*87·8
4302	15·4	74·0	4309	18·2	79·4	4316	17·0	79·1
4303	15·7	73·1	4310	15·3	74·6			
4304	16·6	73·8	4311	16·7	*81·5	Means.	16·8	77·2

The third selection of Folger embraces the family 6817–6830, inclusive, grown on block 45 (1893) with the following pedigree:

Year.	Plat.	Serial No.	In juice.	
			Sucrose.	Purity.
			Per cent.	
1890	P. 126	Average seed.	15·6	75·7
1891	P. 548 (planted from average seed; 1890)	9879	17·2	76·8
1892	B. 58 (planted from serial No. 9879; 1891)	35011	18·0	80·4
1893	B. 45 (planted from serial No. 35011; 1892)	6817–6830		
	Plat average		15·5	78·8

The individual seed heads selected for special propagation in 1894, are 6817, 6819, 6820, 6821, 6826, 6827, and 6828, and are marked with a star. The analyses of the juices of the individual canes bearing these seed heads follow:

Serial No.	Sucrose.	Purity.	Serial No.	Sucrose.	Purity.	Serial No.	Sucrose.	Purity.
	Per cent.			*Per cent.*			*Per cent.*	
6817	15·1	*80·0	6823	14·5	72·3	6829	15·1	63·2
6818	15·6	78·4	6824	15·1	77·5	6830	14·9	74·9
6819	16·1	*83·0	6825	15·3	78·9			
6820	15·7	*83·1	6826	16·6	*87·8	Means..	15·5	78·8
6821	16·6	*87·8	6827	16·2	*81·4			
6822	14·3	71·2	6828	16·2	*83·5			

PROGRESS IN THE DEVELOPMENT OF STANDARD VARIETIES.

The increase in sugar content of the best varieties which have been grown in the past seven years is shown graphically in the accompanying chart. The vertical column of numbers represents percentages of sucrose in the juice. The horizontal columns represent the years from 1888 to 1893, inclusive, and the varieties. The percentages of sucrose in the juice have been obtained by a comparison of all the analyses made, and in no case represent an individual analysis or the analyses of an individual plat.

Not only do climatic conditions exert a powerful influence on the quantity of the crop harvested, but, as is easily seen from the chart and from the comparison of the data of all the years of experiment, they exert also a great influence on the percentage of sucrose. At full maturity the cane which has been grown under proper conditions of temperature and other favorable environment would show a normal percentage of sucrose, and this would represent the actual progress of the sugar content in the process of development. Changes in environment, however, may tend to raise or depress this normal content above or below that which would be expected of normal development. A striking illustration of the raising of the percentage above the normal is shown in the results obtained in 1892. These phenomenal results were due to a fairly favorable growing season in which the plants were well developed, followed by an exceptionally dry autumn with late frosts.

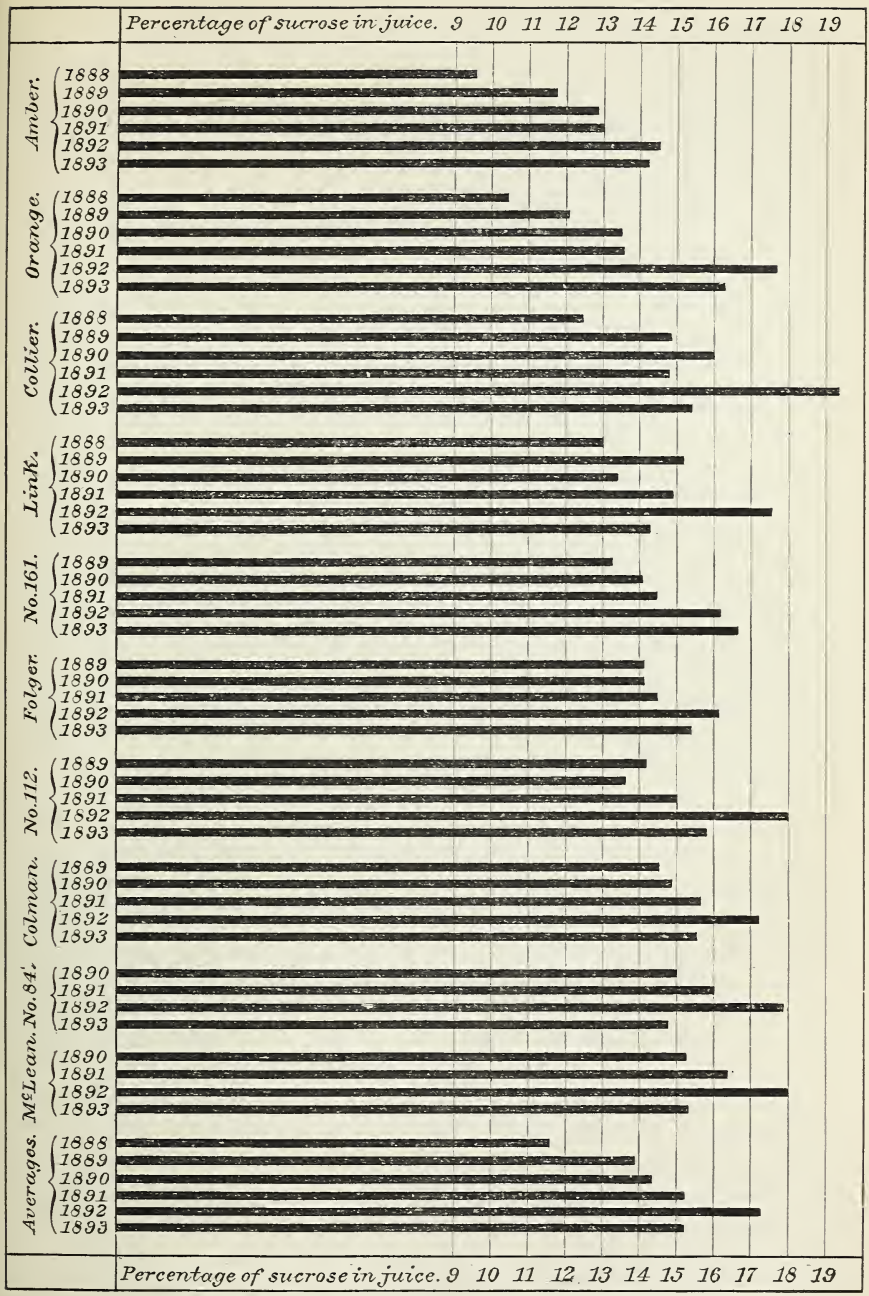

FIG. 1.—Chart showing progress of varieties of cane.

Not only were the plants fully matured by the dry weather, but it is presumed that they were to a certain extent deprived of a portion of their moisture, with a corresponding increase of solid matters. The percentage of sugar in the juice of the plant would thus be correspondingly increased. This increase is most strikingly shown in the case of the Collier cane, the average content of sucrose in the juice of the plants for 1892 being almost 19·5 per cent.

Exactly the opposite forces produced the low content of sucrose in the crop of 1893. In this case the growing season was exceptionally dry and the plants remained almost without development until September. Then, under the stimulus of abundant rains, they grew rapidly, but did not reach maturity in time to escape the blighting frosts, which were somewhat earlier than usual. These seasonal differences, therefore, must be fully considered in studying the effects of selection. In every case we see great progress, when these seasonal differences are eliminated, from a low average content of sucrose at the beginning to a reasonably high average at the close of six years of experimental selection.

A word of caution should be given here in regard to the proper interpretation of the work of selection. It is not expected that natural variations will be continued in the progeny in the full vigor in which they were first observed. All that is to be hoped for is a tendency in the progeny to imitate some of the properties of the ancestor and thus, by the selection and continuation of this tendency, that a gradual progression in the progeny towards the standard of accidental variation in the original parent may be secured.

GENERAL CONCLUSIONS.

The ultimate object of all the investigations which have been made by the Department in the improvement of sorghum as a sugar-producing plant has been the demonstration of the availability of this plant for sugar-making purposes. It may be said in the way of criticism of the work of the Department that the amount of sorghum sugar produced has not increased; in fact, the amount produced in 1893 was less than in 1892. In answer to this attention may be called to the fact that the investment of money during the last fifteen years in sorghum-sugar factories has proved almost uniformly disastrous. Capital is therefore extremely timid at embarking in a business the route of which is marked by so many financial wrecks. In spite, therefore, of the investigations of the Department in pointing out the proper climatic conditions for the growth of sorghum the localities best suited thereto, and in the development of the sorghum plant by the process of selection until it has become a sugar-producing plant of high order, capital has been hesitant and no investments have been made.

The success which has attended the practical work in Spain, as indicated in the report of Heredia and Brothers, shows that the semi-arid regions, or regions suited to irrigation, are in the highest degree favorable to the production of sorghum sugar. Further than this, attention must be called to the great success during the past year of the factory at Fort Scott, Kans., which made a total of 730,172 pounds, almost double the production of any former year.

ADVANTAGES OF USING HIGH-BRED SEED.

If the factories were careful to use only the seed which has been produced by the methods of selection practiced by the Department, it is believed that their product would be greatly increased. It is not meant by this that fields should be planted with specially selected and pedigreed seed heads; this is not at all possible, as the expense of producing the seed in this way would be greater than the grower could afford. It requires, however, only a year or two to produce from a single pedigreed seed head a sufficient quantity of seed to plant many acres. Take, for instance, the collateral branches of Colman now in the possession of the Department. We have now 837 specially selected seed heads descended in direct and indirect carefully selected lines from the original cross. These are all of the highest quality and contain the accumulated effects of the high-bred strain. Only a few of these are desirable for planting for the purpose of continuing the individual pedigree in the further development of the variety. At least 800 of them could be planted in a field for the production of high-bred seed, and this number would plant 20 acres, and each acre of this would produce seed enough to plant 500 acres, or in all 10,000 acres. It is thus seen that the 800 seed heads of the Colman variety, now in the possession of the Department, would in one year produce a sufficient quantity of seed to plant 10,000 acres, or quite enough to supply three or four large factories. The actual cost, therefore, to the grower of the highest bred seed produced in this way would be very slight, while the advantage to his crop would be far-reaching.

CONDITIONS ESSENTIAL TO EXTENSION OF SORGHUM SUGAR INDUSTRY.

There are four conditions which are essential to the successful extension of the sorghum-sugar industry in this country:

(1) The locality selected for growing the cane must be well toward the south and similar in its climatic conditions to the eastern and middle southern tier of counties in Kansas. It would be better even to have them a little farther south than that locality.

(2) The seed used must be produced in the manner mentioned above.

(3) The factories for manufacturing the cane must be of the highest order of workmanship, capable of rapid work without danger of delay.

(4) The fiscal attitude of the Government toward sugar must be favorable.

If these four favorable conditions could be secured there is no reason to doubt the rapid increase in the development of the sorghum-sugar industry until it would become an important factor in supplying the sugar consumption of the country.

RÉSUMÉ OF SEED-SELECTION WORK AT MEDICINE LODGE, 1893.

By Oma Carr.

WORK DELAYED BY DROUGHT AND INSECT INVASIONS.

Owing to the retarding effect of drought and chinch-bug invasions—the latter necessitating many replantings—seed-selection work was begun on September 4, whereas last year the varieties were ready for selection on August 25. In consequence of this lateness of maturation and the imminence of frost many selections from the later varieties were made, not on quality of the canes but upon their degree of ripeness, reversing the usual selection methods. It was feared, at one time during the season, that several plats would not ripen sufficiently before being struck by frost, and that selections from them—representing, many of them, the very cream of the fine seed selected last season—must be lost. Fortunately, however, fine weather during the last two weeks of the season hastened the ripening to such a degree that selections were secured from every variety planted in such number as to insure continuance of the pedigree.

The extent to which the varieties were retarded by the unfavorable season and chinch-bug attacks may be seen in a comparison of the dates on which selection work was commenced last season and this, thus:

Dates on which seed-selection work was commenced in 1892 and 1893.

Variety.	1892.	1893.
Amber	Aug. 25	Sept. 4
No. 161	Sept. 2	Sept. 14
Folger	Sept. 6	*Aug. 29
Colman	Sept. 6	Sept. 28
African	Sept. 17	.....
Collier	Sept. 22	Oct. 6
No. 160	Sept. 24	.....
No. 112	Sept. 26	Sept. 25
Link	Sept. 28	.....
Link crosses	Sept. 30	Oct. 6
No. 8X	Oct. 1	Oct. 6
McLean	Oct. 4	Sept. 2
Orange	Oct. 5	Sept. 27
No. 289	Oct. 8	.....
Planter	Oct. 10	.....
Link and Amber	Oct. 12	.....

* A block of Folger saved from chinch bugs.

The above table fails to be perfectly comparative, because on the dates given the compared varieties were not matured in the same degree in the two years. Had we waited for the varieties to have reached the same stage of maturity as in the previous season we should have lost selections from several of the later canes. Consequently, this season's cane was considerably later than shown by the table.

SOME BENEFITS OF SEED SELECTION.

During the season there were selected 14,956 seed heads against 49,912 last season, or a total during the existence of the Medicine Lodge Station of 64,868, sufficient to

plant, at the rate of 40 per acre, 1,682 acres. Assuming a good season and fair agricultural treatment, the product of this area would reach 10,000 tons, worth, on an average valuation, $20,000, or a revenue of $12 dollars per acre from seed whose approximate cost was $1.20. Perhaps the benefit of seed selection may be better appreciated when it is stated that, comparing the character of the canes of 1888 and 1893, the value of the former, on the scale of prices now prevailing, would hardly approximate 65 per cent of the present value. In other words, the value of the cane to the farmer is 35 per cent greater than would have been the case had the cane not been improved by selection work. It is likely, also, that the early efforts to utilize sorghum as a sugar-producing plant would have had no considerable encouragement had not systematic selection promised to raise the plant to the grade of its probable competitors, sugar cane and the beet.

The selections made the past season were distributed among the varieties as follows:

Selections from different varieties in 1893.

	Number.
Amber	1,100
Folger	2,964
McLean	345
Colman	868
Link	260
Orange	1,597
No. 112	1,757
No. 161	151
No. 8X	473
Collier	5,441

VARIETIES HERETOFORE CULTIVATED.

Season of 1888.—In the season of 1888 the following varieties were cultivated: Amber (Black, White, and Early), Folger's Early, Swain's Early Golden, Early Tennessee Whiting's Early, Chinese (under several names), White India, White Mammoth, Orange (Early, Kansas, New Late, Medium), Liberian (Red, Golden Rod, Honey Dew, Deutcher's Hybrid, Link's Hybrid, Price's Hybrid, and Planter's Friend), Honduras (Silver Top, Texas Red, Waubansee, and White's African), and 21 unnamed varieties.

Season of 1889.—For the work of 1889 many of the preceding were dropped and a number of new varieties planted as follows: Folger's Early, Link's Hybrid, Planter's Friend, Honduras, Early Honduras, Sorghum Bicolor, Early Orange, Early Amber, Late Orange, Chinese Imphee, Crosses Amber and Orange, Link's Hybrid and Amber, Link's and Orange, Link's and Red Liberian, Variation of Link's, Early Tennessee, Red Liberian, Kansas Orange, New Orange, 5 Chinese varieties, Undendebule, White India, White Mammoth, Ubehlana, Texas Honey Drip, Price's New Hybrid, White African, Black African, White Enfield, Ufatane, Uboyana, Dendemuka, Large Gooseneck, Ukabana, Ungatubanda, Iowa Red-top, and 5 unnamed varieties.

Season of 1890.—In 1890 the following were planted and selected from: Colman, No. 160 and No. 161, Folger's Early, Undendebule (Nos. 1 and 2), Link's Hybrid, White India, Honduras, Ubehlana, White African, Whiting's Early, Black African, White Enfield, Chinese, Sorghum Bicolor, Price's New Hybrid, Jyangentombi, Sorghum Bleu, Honey Drip, Ufatane, Large Gooseneck, Early Gooseneck, Ukubana, Early Amber, Orange (Early, Late, Kansas, New, Improved, and Rio Blanco), Golden Orange, No. 208, No. 244, Deutcher's Hybrids (1, 2, and 3), Honey Dew, Chinese Imphee, No. 350, Nos. 126 and 127 (named McLean next season), No. 289, No. 112, No. 110, Ungatubanda, Dendemuka, Early Tennessee, Planter's Friend, Liberian, Alapore Jowar, and crosses Amber and Orange, Amber and Link's, Amber and White India, Orange and White India, Orange and White African, Orange and

Link's, Link's and White India, Link's and Red Liberian, Link's and White African.

Season of 1891.—In 1891, the following, derived from seed of previous season: McLean, Collier's (Undendebule No. 1, previous season), Link's Hybrid, Colman, Link's Hybrid Crosses, India and Orange, No. 161, Planter's Friend, Early Orange, No. 112, Folger's Early, No. 70, Link's and Amber, Undendebule, No. 2, No. 160, White Mammoth and Orange, Chinese Imphee, Special Ubehlana, Black African, Kansas Orange, Golden Orange, Early Amber, No. 110, White Mammoth and Link's, Link's and Orange, Ubehlana, Bicolor, Kansas Orange and Link's, Dendemuka, Honey Dew, Link's and India, White Enfield, Giant Honduras, Ufatana, Alapore Jowar, Honduras, Reversion to Amber and Link's, Link's selections 174, 165, 163, 162, 5X, 8X, 116, 30, 153, 66, 172, 206, Varieties No. 350, No. 373, No. 208, selection 15X and Var. No. 91.

Season of 1892.—In 1892 the nomenclature of the varieties was revised and the following varieties selected from: Collier, India and Orange, Orange, McLean, 7X, Planter, Colman, Imphee, 592X, No. 161, 14X, African, Ubehlana, 341X, 292X, 42X, 8X, 110X, 15X, No. 208, No. 112, 107X, 401X, Link, 5X, No. 491, No. 227, 23X, Seedless, 6X, Kansas Orange, 142X, Folger, No. 289, 48X, 180X, 165X, Hottinger, 426X, 206X, Amber, 424X, 168X, 43X, Koombana, 67X, Brown, 27X, 232X, and 187X (variety indicated by "No." and cross by "X").

Season of 1893.—In 1893 the Sterling Station was discontinued, and at the Medicine Lodge Station only the following varieties were planted: Amber, No. 161, Folger, Colman, African, Collier, No. 112, Link, Link X's, 8X, McLean, Orange, Planter.

PROGRESS OF THE VARIETIES.

As nearly as can be approximated, the following analyses represent the progress of the varieties since their primary selection:

Statement showing progress of varieties, 1888–1893.

Variety.	1888.		1889.		1890.		1891.		1892.		1893.	
	Sucrose.	Purity.	Sucrose.	Purity.	Sucrose.	Purity.	Sucrose.	Purity.	Sucrose.	Purity.	Sucrose.	Purity.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Amber	9·5	63·0	11·7	74·0	12·8	71·0	12·9	72·0	14·5	76·0	14·3	63·4
Folger	.....	.....	14·1	77·0	14·1	75·0	14·6	73·0	16·1	74·0	15·4	68·0
Colman	.....	.....	14·6	76·0	14·9	76·0	15·6	76·0	17·2	75·0	15·5	75·0
Collier	12·3	72·0	14·9	77·0	16·0	75·0	14·8	74·0	19·4	82·0	15·4	73·0
McLean	.....	.....	.....	.....	15·2	76·0	16·4	77·0	18·4	78·0	15·2	77·0
Link	13·0	73·0	15·2	79·0	13·4	72·0	14·9	73·0	17·6	78·0	14·3	73·3
No. 8X	.....	.....	.....	.....	14·9	75·0	16·0	76·0	17·9	81·0	14·8	78·0
No. 112	.....	.....	14·2	76·0	16·3	75·0	15·0	74·0	17·4	74·0	15·8	70·0
No. 161	.....	.....	13·2	77·0	14·0	76·0	14·6	75·0	16·3	75·0	16·6	60·0
Orange	10·4	63·0	12·1	71·0	13·5	72·0	13·6	68·0	17·7	80·0	16·2	80·0
Means	11·6	68·6	13·9	76·5	14·4	73·8	15·2	74·5	17·3	77·9	15·2	72·0

A better representation of the actual progress of the varieties should exclude the season of 1893, inasmuch as the analyses given for 1893 do not represent canes by any means as equally matured as those of previous years. As explained before, the season of 1893 was such as not only to retard development of the varieties, but to injure their character. The accompanying diagram (page 25) will illustrate the progress of the varieties, together with the effect of the season of 1893. In the diagram based on sugar content of the canes it is seen that the average of all varieties shows constant increase up to the season of 1892, when it falls from 17·3 to 15·2. It may be remarked, also, that, up to 1891, selection was based principally upon sugar content, while, for the planting of 1892, selection included both sugar character and purity of juice.

NOTES ON THE FIELD WORK AT MEDICINE LODGE.

By C. I. Hinman.

At the Station all of the first planting, except Block No. 32, was totally destroyed by chinch bugs on June 14 and 15; that one block was saved, from the fact that it was practically isolated from the alternating blocks of wheat, so that the insects were delayed in entering it until cholera-infected bugs could be secured and scattered. The chinch bugs and dry weather have made sad havoc with the cane on all the plats; if there had been plenty of rain the bugs would not have materially affected the cane; and again, if the bugs had not attacked it the cane would have been a fair crop—one emphasized the other.

TEMPERATURE AND RAINFALL.

This spring was diametrically the opposite of the spring of 1892; that one was cold and wet, while last spring was exceedingly hot and dry; no rain in March and April, and very light showers in May—not enough to lay the dust until the 14th—eighty days with a scorching sun and high winds, with not a drop of rain. During May there were 2.18 inches of rain, but it fell in such light showers that it did no permanent good. The month was very hot and windy. In June, 1.21 inches of rain fell, and again in very light showers; this month was very hot, with hot winds on several days. In July, 1.44 inches of rain fell, with high and hot winds prevailing; light showers. In August, there were 2.25 inches of rain, with exceedingly hot weather and hot winds, the thermometer frequently standing at 100° and 105°; light showers. In September, 3.40 inches of rain fell; during this month, the first time since the cane was planted, the ground had been wet to a depth of 4 inches, and as a result cane made wonderful and rapid strides. In October, 14 inches of rain fell; light frost on the 3d and 5th—no damage, but on the 8th it killed the leaves.

Cane that was planted April 10, 11, and 12 did not come up until May 16, 17, and 18, for the reason that the ground dried out so completely that there was not enough moisture to germinate the seed. The first shower that did any good occurred on the evening of May 14, when rain fell to the depth of 0.58 of an inch.

DETAILS OF THE CULTURAL WORK.

The following is a detailed account of the cultural work of the season:

Block No. 2, Station.—Planted to Folger on the 10th of April, by hand, after it had been plowed to a depth of 12 inches on the 8th; then immediately harrowed, rolled, and reharrowed. This first planting was totally destroyed by chinch bugs. Replanted with Amber July 3, with lister, in rows 3 feet 7½ inches apart. This block was 1,000 feet long. Eight of the rows were planted with 80 seed heads (200 feet to a seed head), and the remainder of the block with 7½ pounds of bulk seed. It came through the ground in three days, and when about 6 inches high was thinned by hand, leaving the best and most vigorous stalks from 3 to 6 inches apart. It was in full head August 22, cut and delivered to mill October 6 and 9. It was cultivated five times, hoed three times, and harrowed two times.

Block No. 8, Station.—Planted with Collier, by hand, on April 11, having had same preparation of seed bed as block No. 2. This was also totally destroyed by chinch bugs, and was replanted with Collier again on July 3, with lister, using 7 pounds of bulk seed from block 17. It came up in three days, and was thinned and cultivated same as block No. 2. It was not fully matured when the frost of October 8 killed the leaves, and for this reason we did not take any samples from it; cut and sold for fodder November 1 and 2.

Block No. 14, Station.—Planted with Colman, by hand, April 12. Seed bed prepared same as before. Destroyed by chinch bugs; and replanted with Colman,

July 1 and 3, with lister in rows 3 feet 7½ inches apart, using 120 seed heads (200 feet to seed head). Cane came up in 4 days, and headed out September 15. It was cultivated and thinned same as block No. 2. The frost of October 8 also caught this block before the cane was fully matured, and for that reason we took but few samples from it. Cut and sold for fodder November 1 and 2.

Block No. 20, Station.—Planted with Link's Hybrid April 12, by hand, using 110 seed heads, each head planting 200 feet; the rows 3 feet 7½ inches apart, and the hills 2½ feet. Same preparation of seed bed as before. This was also destroyed by chinch bugs, and replanted with Link's Hybrid June 30 with lister, using 110 seed heads from parent block 78. The cane came up July 5 and was heading out September 15. It had same cultivation and thinning out as block No. 2. The frost also caught this plat before it was fully matured, and for this reason but few samples were taken from it. It was cut up for fodder November 1 and 2.

Block No. 26, Station.—Planted with McLean April 13, by hand; seed bed prepared as before, using 120 seed heads, each head planting 200 feet. This plat was destroyed by chinch bugs and replanted with Folger, June 30, with lister, using 120 seed heads from parent block 5. The cane came up July 5 and was heading out September 4. It had same cultivation and thinning out as block 2. Frost caught this block also before it was fully matured; no samples taken. It was cut for fodder November 1 and 2.

Block No. 32, Station.—Planted with Folger April 13, by hand, in bottom of lister furrows, 3 feet 7½ inches apart, and the hills 2½ feet apart; seed bed prepared same as block No. 2. This is the one block on the Station that was saved from chinch bugs, after a long and hard fight with them. The country was full of them, but by frequently scattering cholera-infected bugs the block was at last saved. The block adjoining on the north side was vacant and the one on the south side was in oats; consequently a large number of bugs was gathered and inoculated before they got into it. The cane came up June 4 and was heading out July 24; commenced sampling August 28; weight of samples, 3 tons. This block was remarkably hardy and vigorous, considering the intensely hot and dry season. It contained just 2 acres, and the upper two-thirds of 120 seed heads from parent block No. 5 were used in planting it, each head planting 200 feet. It had same cultivation as block 2, but in thinning it out from 5 to 6 of the best and most vigorous stalks were left in each hill.

Block No. 38, Station.—Contains just 2 acres, and was planted with Collier, in bottom of lister furrow, by hand, with upper two-thirds of 240 seed heads; each head planting 100 feet. It was planted April 14, but did not come up until May 14, and was destroyed by chinch bugs June 14. After the bugs had all disappeared from the plat, it was replanted with Collier, June 30, using a lister, 101 seed heads from parent block 89 (second choice bulk) and 107 seed heads, same parent block (first choice bulk). The cane came up July 4, and was heading out September 12. Commenced sampling October 15. Weight of samples, 3½ tons. This block had same preparation of seed bed, cultivation, and thinning, as block 2; it was remarkably vigorous, considering the season. What was left after sampling was cut for fodder, November 1 and 2.

Block No. 44, Station.—Contains 2 acres, and was planted with Colman, by hand, in bottom of lister furrow, using 120 seed heads from parent block 60. It was planted April 15, but cane did not come up until May 22. The first planting on this block was also destroyed by chinch bugs, and was again planted with Colman June 29, using 110 seed heads from parent block 11, and 10 heads from 60. Cane came up July 3, and was heading out September 8. Commenced sampling October 16. Weight of samples, 2 tons. The replant was very vigorous from start to finish, and made a remarkably strong and rank growth, considering the very hot and dry season. Cut for fodder, November 1 and 2. Preparation of seed bed, cultivation, and thinning, same as block 2. The very interesting experiment of testing the relative vitality of the upper, middle, and lower thirds of each head, was destroyed by the chinch bugs, and

as it was so late in the season it was not deemed advisable to renew the experiment. The value of having the Station plowed and subsoiled to a depth of 18 inches in the spring of 1891 was made very conspicuous; it certainly had the crucial test applied to it this year. Crops grown on the same kind of soil, not only adjoining the Station but throughout the country, were, in almost all cases, a total failure, or nearly so. Some farmers replanted their cane four times, and had no crop; while on the Station the cane came up and made a good, strong, and vigorous growth from start to harvest; clearly demonstrating the importance of deep plowing, and of observing well-established practices in the manner and method of planting, cultivating, and thinning the crop.

Block No. 45, Farmer.—Planted with McLean from parent block 58, by hand, April 12 and 13, in bottom of cultivator furrow, the rows 3 feet 7½ inches apart, and the hills 2½ feet apart, using 60 seed heads. This was plowed, April 11, 6 inches and subsoiled 8 inches; then harrowed two times. It was cultivated five times and hoed twice. Owing to the extremely dry weather, the cane did not come up until May 16; we had a shower of 0.58 of an inch on the 14th. When the crop was about 5 inches high it was thinned out by leaving from 5 to 6 of the best and most vigorous stalks in each hill. It headed out July 24 and was sampled October 2. Weight of samples, 950 pounds. The west end and center were high ground and slightly inclined to be sandy; on this the cane was small, but on the lower portions the cane was fairly good.

Block No. 46, Farmer.—Planted with Amber, using 80 seed heads, as follows: 76 from parent block 81, and 4 from parent block 74; each seed head planting 150 feet. Preparation of seed bed, planting, and thinning same as block 45. Planted April 14, cane up May 19, headed out July 17; commenced sampling September 4; weight of samples, 1,600 pounds.

Block No. 47, Farmer.—Planted with variety No. 112, using 60 seed heads from parent block 73. This was plowed 6 inches, and subsoiled 8 inches; harrowed 2 times, cultivated 5 times, and hoed 2 times. Planted April 15, by hand, in bottom of cultivator furrow, in rows 3 feet 7½ inches apart, the hills 2½ feet apart. Cane was up May 20; when about 6 inches high, it was thinned out, by leaving from 5 to 6 of the best and most vigorous stalks in each hill. Commenced sampling September 25. Weight of samples, 4,000 pounds. This is undoubtedly a fine variety of cane, it withstands dry and hot weather remarkably well, and is a vigorous grower; is large and stalky, and consequently stands up well; the head is compact and yields a good crop of seed.

Block No. 48, Farmer.—Planted with variety 8X, using 60 seed heads from parent block 85. Preparation of seed beds, method of planting, cultivating and thinning same as block 47. Planted April 19, cane up May 22. The chinch bugs damaged this plat on the east side—it adjoined a wheat field. Sampled October 6; weight of samples, 1,050 pounds.

Block No. 49, Farmer.—Planted with variety 161, using 25 seed heads from parent block 66, and 35 heads from block 52. The preparation of seed bed, method of planting, cultivating, and thinning, same as block 47. Planted April 18, cane up May 19, headed out July 20; sampled September 14; weight of samples, 450 pounds.

Block No. 50, Farmer.—Planted with Collier, from parentage as follows: 51 heads from block 96, 29 heads from block 92 and 40 heads from block 89; each head planting 100 feet. Preparation of seed bed, method of planting, cultivating, and thinning, same as block 47. Planted April 20, cane up May 20, headed out August 5, sampled October 6; weight of samples, 100 pounds.

Block No. 51, Farmer.—Planted with Colman, using 38 seed heads from parent block 41, and 22 from parent block 60. Preparation of seed bed, method of planting, cultivating, and thinning, same as block 47. Planted April 24, cane up May 22; headed out July 28; commenced sampling September 28; weight of samples, 1,400 This block was on high upland, and the dry weather and chinch bugs damaged the crop badly.

Block No. 52, Farmer.—Planted with Colman, using 60 seed heads from parent block 60. Preparation of seed bed, method of planting, cultivating, and thinning, same as block 47. Planted April 25; cane was up May 22; sampled October 5; weight of samples, 200 pounds. This block was also on high upland, and was badly damaged by chinch bugs and dry weather.

Block No. 53, Farmer.—Link crosses, using sixty seed heads from parent block 61. Preparation of seed bed, method of planting, cultivation, and thinning, same as block 47. Planted April 25, cane up May 22; headed out August 18; commenced sampling September 29; weight of samples, 925 pounds.

Block No. 54, Farmer.—Planted with orange, using 80 seed heads from parent block 50. This block was plowed 8 inches deep, and subsoiled 6 inches April 28 and 29, and harrowed, then laid out with lister in rows 3 feet 7½ inches apart, and planted by hand in bottom of lister furrow, planting it in hills 2½ feet apart, dropping from 10 to 12 seeds in each hill. When the cane was about 6 inches high, it was thinned out, by leaving from 5 to 6 of the best and most vigorous stalks in each hill. Cultivated 5 times and hoed 2 times. Crop was up May 19; commenced sampling September 27; weight of samples, 3,225 pounds. The chinch bugs damaged this plat on the east side—it adjoined a field of small grain on that side.

The last two seasons were very unfavorable ones for raising cane, and the last one especially so, owing to the extremely hot and dry weather accentuated by chinch bugs.

SORGHUM-GROWING IN SPAIN.

During the early part of 1893 M. Heredia and Brothers, of Malaga, Spain, procured from the Department a large quantity of high grade bulk sorghum seed, grown at Medicine Lodge. They were impressed with the belief that the climate and soil of Southern Spain in many respects resembled those of Kansas. They therefore determined to plant a considerable quantity of sorghum, of the best approved varieties, for actual sugar-making experiments in their factory, built originally for the production of sugar from sugar cane. A promise to report the results of their work accompanied their request for seed. The following interesting report has been received from them in compliance with that promise:

REPORT OF HEREDIA Y HERMANOS.

MALAGA, *December 11, 1893.*

Prof. H. W. WILEY,

U. S. Department of Agriculture, Washington, D. C.:

DEAR SIR: We had the pleasure to address you on the 20th of May last, and desire now to fulfill our former promise to give you an account of our experiments with sorghum this summer and autumn:

Condition of seed when received.

As we told you in our last, the seed we received from Kansas having been heated on the way had lost in great part its germinating power, and unfortunately the Colman seed was the one received in worst condition. Notwithstanding this, by planting ten times the usual quantity we succeeded in having two fields of Colman cane—one ripe at the beginning of September and the other at the end of October. The Folger's Early was the seed that came in the best condition, and of this seed we sowed the greatest part.

In our climate, with irrigation, Folger's cane grows very slender; it has also the great disadvantage that as soon as it is ripe the cane gets dry and the interior becomes hollow, and it has less sugar and purity and more starch than any of the others. The molasses has finer flavor, but this is of little importance here.

We began working on the 5th of September with about 15 tons of Folger's Early and 6 tons more of Collier, Black African, and Link's Hybrid.

Trials with different varieties.

Having just finished working our beet roots, we had in working order our lime-kiln, and this led us to begin our trials with carbonatation. Unfortunately, Folger's cane had been exposed to the sun during two days, and it was impossible to filter the juice through the filter presses. We then made a trial with Collier's cane, which at first filtered well, but after two hours it also slackened, and it became impossible to continue with the work. By trying all sorts of methods, we succeeded after two days in passing the juices through the presses. We tried cold and warm carbonatation, defecation with lime and then carbonatation, etc., but all were useless, and the juices would not pass the presses. Upon the cloths there was scarcely 1 millimeter of slimy matter. These juices would not even decant clear. We were compelled to boil the sirups without eliminating the various precipitates of lime formed. We lost nearly all the cane employed.

After this we changed our system of working. The juice from the mill after the canes were repressed with 30 or 35 per cent of warm water (this was also done on the first trial) was sent to an old defecating tank where lime was added to neutralization, then boiled, skimmed, and filtered through megass filter and evaporated. The sirup was sent to copper defecators, where it was sulphated, then filtered through animal charcoal and boiled in the vacuum pan.

With the Colman's cane, which had 14 per cent of sugar and 74 purity, we were able to crystallize in the pan without adding any sugar. We obtained 11 per cent of massecuite and 4 per cent of first sugar, light brown and polarizing 95°. We expect to obtain 1 to 1¼ per cent of second sugar.

With the same process we worked two more lots, one of 200 tons of Folger's cane in good condition, 11 per cent sucrose and 68 purity. We obtained 11 per cent massecuite with 4 per cent first sugar and could not estimate the second. It would not crystallize in the pan, so we added 20 to 25 per cent of beet-root sugar of third jet.

The other trial was of about 600 tons of Folger's, Link's Hybrid, McLean, and Black African all mixed together. We obtained 11·38 per cent massecuite and a little over 4 per cent first sugar and 1·35 per cent second sugar.

Link's Hybrid and McLean were superior in sucrose and purity to the other two. We added also some beet-root sugar. All these canes were worked with very dry weather, the nights being as dry as the days.

On the 19th October, after several nights in which dew fell heavily, we worked 264 tons of Colman, 14 per cent sugar and 72 purity. The cane passes well through the mills (the others had done it with difficulty); we added in repression all the hot water we could, worked as before, and had a better result. We had added only a small quantity of beet-root sugar.

It crystallized easily in the pan, and we had 12 per cent of massecuite. After centrifugaling dry we obtained 4·75 per cent of first sugar, clear brown. Calculating we can get 1·25 to 1·50 per cent second sugar, we estimate the total to be about 6 per cent.

The seed heads* you had the kindness to send us have been planted with great care in plats apart, but in the same acre. They have given us the following very satisfactory results:

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*These were high-bred pedigreed seed heads.

Superiority of the Colman variety.

Of all the different varieties the one that on equality of circumstances has given here the best results is the Colman. Physically, if not the largest, it was the strongest and gave a larger quantity of seed; chemically it had more sugar and a purity far superior to any other variety. The Collier had a greater density but was inferior in sugar and purity. With the means at our disposal it was very difficult to study many sorts at a time, so we abandoned all others and kept only the Colman for further experiments.

The results of all the analyses made from the Colman plat are as follows:

All the canes chosen for selection weighed when topped and clean of leaves from 900 g. to 1 kilo. All the analyses were made on single canes by means of a small but strong handmill. The maximum of sugar in the juice was 19·82; minimum, 15.72. The maximum of purity, 84·8; minimum, 71·30.

Of all the single canes analyzed from the Colman plat—

1·72 per cent of the canes had from 15 to 16 per cent sugar in the juice.
6·90 per cent of the canes had from 16 to 17 per cent sugar in the juice.
16·38 per cent of the canes had from 17 to 18 per cent sugar in the juice.
53·45 per cent of the canes had from 18 to 19 per cent sugar in the juice.
21·55 per cent of the canes had from 19 to 20 per cent sugar in the juice.

100·00

The purity of the juice was as follows:

11·21 per cent did not reach 80 of purity.
21·55 per cent did not reach 80 to 81 of purity.
32·76 per cent did not reach 81 to 82 of purity.
20·63 per cent had from 82 to 83 purity.
10·34 per cent had from 83 to 84 purity.
3·45 per cent had from 84 to 85 purity.

The average weight of clean seed per head was 130 g.

The Colman, as well as all the other varieties, had a great tendency to suckering, many of the canes having 3 and even 4 seed heads which reached maturity.

The best 15 analyses made from the Colman are:

Results of 15 analyses of Colman cane.

Number.	Density at 15° C.	Sugar in the juice.	Purity.
	B°.	*Per cent.*	
1	8·75	19·39	83·65
2	8·65	19·35	84·40
3	8·55	19·00	83·90
4	8·50	18·92	84·10
5	8·65	19·21	83·80
6	8·95	19·82	83·60
7	8·85	19·55	83·40
8	8·60	19·00	83·40
9	9·00	19·62	82·30
10	9·05	19·60	81·80
11	8·75	19·32	83·30
12	8·60	19·01	83·40
13	8·90	19·82	84·00
14	9·00	19·82	83·10
15	8·70	19·57	84·80

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